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June 1978

ENERGY RECOVERY FROM SOLID WASTE IN THE CHARLESTON, SC, SMSA

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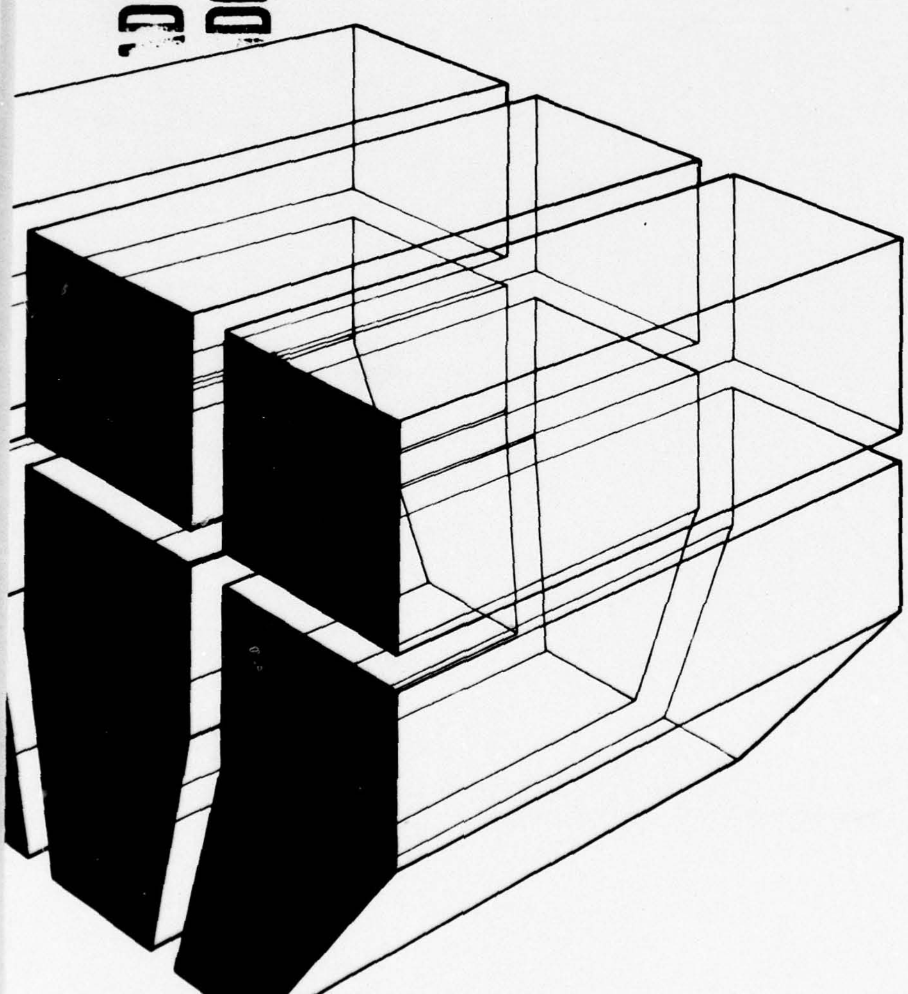

by
A. N. Collishaw
S. A. Hathaway

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This study investigated the technical and economic feasibility of establishing a single, solid waste resource-recovery facility in the Charleston, SC, Standard Metropolitan Statistical Area (SMSA). Energy was the primary resource to be recovered. The 29,700 tons/year of solid waste generated by Federal facilities in the SMSA are presently being disposed of in landfills operated by county governments. This study compared the cost of continuing solid waste disposal by landfill to the

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estimated cost of establishing (1) a Federal resource-recovery facility or (2) a regional resource-recovery facility.

10 to the 10th power

When a Federal resource-recovery facility which used solid waste generated by Federal facilities only was considered, it was determined that energy could be recovered at a rate of 19.0×10^{10} Btu/year. The capital investment was estimated to be $8.5 million in FY82 dollars and the Savings to Investment Ratio (SIR) was estimated at 0.8/1.0, with a payback period of more than 25 years. Because the SIR was less than 1.0, this study concluded that a Federal resource-recovery facility was not economical and should not be pursued.

The regional resource-recovery facilities considered in this study used a processed solid waste known as refuse-derived fuel (RDF) produced at the Charleston County Shredder Facility (CCSF). Waste from both the civilian community and Federal facilities, currently being shredded at CCSF and landfilled nearby, would supply the proposed facilities. It was determined that energy could be recovered at the rate of 77.8×10^{10} Btu/year. The capital investment was estimated to be $14 million in FY82 dollars. Based on a cost of $3.00/ton (FY82 dollars) for RDF, the SIR was calculated to be 1.8/1.0, with a payback period of 5.5 years.

Charleston County would realize an increase in revenue of $260,000 (FY82 dollars) based on the sales price of $3.00/ton for RDF.

This study recommended that a regional resource-recovery facility fueled by RDF purchased from CCSF be built at the Charleston Naval Shipyard complex.

If the recommended facility cannot be established, the present practice of using county facilities for the disposal of Federally generated mixed solid waste should be continued.

SUMMARY

OBJECTIVE

The objective of this study was to determine the technical and economic feasibility of resource recovery (both of energy and materials) at a single resource-recovery facility in the Charleston, SC, Standard Metropolitan Statistical Area (SMSA). Two types of resource-recovery facilities were considered: (1) a Federal resource-recovery facility which would use waste from Federal facilities only, and (2) a regional resource-recovery facility which would use processed solid waste generated from both the civilian community and Federal facilities.

SOLID WASTE GENERATION

This study determined that an estimated 114 tons/day (5 days/week basis) of solid waste are generated by Federal facilities within the Charleston, SC, SMSA. The energy available from Federal facilities alone is 10 x 10^8 Btu/day. The Federal facilities considered part of the SMSA are: Charleston Naval Shipyard Complex; Charleston Air Force Base; Naval Weapons Station and Missile Facility; Naval Regional Medical Center; Charleston Army Depot; the Veterans Administration (VA) Hospital; the U.S. Coast Guard; and the General Services Administration.

CURRENT WASTE DISPOSAL OPERATIONS

Solid waste generated at the Federal facilities located in the SMSA is collected and hauled to the Charleston County Shredder Facility (CCSF) or to landfills operated by Charleston and Berkeley Counties. The Charleston County landfill is nearly at capacity and another, more distant landfill will have to be established soon. The present cost to collect and dispose of mixed solid waste (MSW) generated by Federal facilities in the Charleston SMSA is $704,000/year.

ENERGY-RECOVERY ALTERNATIVES

One energy-recovery alternative was evaluated using only solid waste generated from Federal facilities. Two alternatives were evaluated using solid waste generated from both the civilian community and Federal facilities. In the latter alternatives, waste from Federal facilities will be hauled to CCSF; shredded waste from CCSF will be purchased for use in a Federally built and owned energy-recovery facility. The costs and energy-recovery potential of three alternatives were then rated against the costs of landfilling waste -- the present waste disposal method.

Of the three energy-recovery alternatives evaluated, all employ site-erected waterwall furnaces. The initial handling of waste is by front-end loader. The material is fired on a double reciprocating grate stoker. Quenched ash is stored until its removal to landfill.

For all alternatives, the recommended plant location is adjacent to the proposed refuse segregation, holding, and processing facility near the intersection of Halsey Street and Bainbridge Avenue, at the Charleston Naval Shipyard. Steam is piped approximately 4000 ft to the existing main header near the corner of Halsey Street and Hobson Avenue. In accordance with NAVFAC Document P-442,[1] the present value (PV) method of economic analysis was used. Short-term and long-term differential escalation rates used are as specified by DOD policy.[2] A discount rate of 10 percent was employed. Analyses were carried out for a project economic life of 25 years (FY82 to FY07). Table A summarizes the economic analysis of the four alternative resource-recovery systems.

Alternative A: Continue Present Practice

This is the baseline alternative against which the costs and benefits of resource-recovery alternatives were compared. Present and proposed county facilities are adequate to accommodate future waste generation over the long term. This alternative requires no major capital investment. The 25-year PV cost of this alternative is $9,880,000, including contracts, collection costs, and dump fees. However, there is no energy recovery with this alternative. Charleston County presently landfills the RDF produced at CCSF.

Alternative B: Federal Resource-Recovery Facility

This alternative includes two site-erected waterwall incinerators to fire shredded solid waste generated by Federal facilities in the Charleston, SC, SMSA. Steam production will be 60,000 lb/hour. Operation will be two shifts/day, 5 days/week, allowing the remainder of the week for maintenance and peak load processing. Approximately 26.2×10^{10} Btu/year will be conserved by processing 23,000 tons/year Federal solid waste. This is equivalent to 16 percent of the heat distribution system at the South Yard of the Naval Shipyard Complex and site of the

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1 *Economic Analysis Handbook*, NAVFAC DOCUMENT P-442 (Naval Facilities Engineering Command, 1971).

2 *Revised Energy Conservation Investment Guidance*, DOD telegram 17 April 1977; communication to the U.S. Army Construction Engineering Research Laboratory (CERL) from Directorate of Facilities Engineering, Office of the Chief of Engineers, Washington, DC, 17 April 1977.

Table A

Summary of Energy-Recovery Alternatives

Alternative	Processed (tons/yr)	Design Steaming Capacity (lb/hr)	Percent of System Heating Load	Capital Investment ($)	SIR	Years to Payback
A The present practice of disposing solid waste in landfills operated by the counties.	29,700	-	-	-	-	-
B Energy recovery from Federal solid waste.	23,000	60,000	16	8,500,000	0.81	25+
C Energy recovery from Federal and civilian solid waste, Level I.	69,900	160,000	41	13,900,000	1.30	13
D Energy recovery from Federal and civilian solid waste, Level II.	86,800	150,000	50	14,040,000	1.86	5.5

proposed resource-recovery facility. Compared to baseline Alternative A, this system has an SIR of 0.81 and a corresponding payback period of more than 25 years. The required investment is $8,500,000 (FY82 dollars).

Alternative C: Regional Resource-Recovery Facility, Level I

This alternative includes two site-erected waterwall incinerators firing coarse-shredded, ferrous-depleted solid waste. Material will be received from CCSF on an "as required" basis to meet the steaming requirements. Steam production will be 160,000 lb/hour. Operation will be two shifts/day, 6 days/week, allowing the remainder of the week for maintenance and peak load processing. Approximately 62.6×10^{10} Btu/year will be conserved by processing 69,900 tons/year of Federal and civilian solid waste. This is equivalent to 41 percent of the annual heating load of the heat distribution system at the South Yard of the Naval Shipyard Complex and site of the proposed resource-recovery facility. Compared to baseline Alternative A, this system has an SIR of 1.30 and a corresponding payback period of 13 years, based on a purchase cost of $3.00/ton for RDF. The required investment is $13,900,000 (FY82 dollars).

Alternative D: Regional Resource-Recovery Facility, Level II

This alternative includes two site-erected waterwall incinerators to fire coarse-shredded, ferrous-depleted solid waste. Material will be received from CCSF. The operation will be similar to Alternative C; however, there will be more operational hours per week and a lower steaming capacity (150,000 lb/hour). Operation will be three shifts/day, 5 days/week, allowing 2 days for maintenance and/or peak load processing. Approximately 77.7×10^{10} Btu/year will be conserved by processing 86,800 tons/year of Federal and civilian solid waste. This is approximately 50 percent of the annual heating load of the heat distribution system at the South Yard of the Naval Shipyard Complex and site of the proposed facility. Compared to baseline Alternative A, this system has an SIR of 1.86 and a corresponding payback period of 5.5 years, based on a purchase cost of $3.00/ton for RDF. The required investment is $14,040,000 (FY82 dollars).

CONCLUSIONS

This study shows that it is technically feasible to recover energy from solid waste in the Charleston, SC, SMSA.

It was determined that a Federal resource-recovery facility (Alternative B) is not economical and should not be pursued.

The regional resource-recovery facility, Level II (Alternative D) is the energy-recovery system with the best SIR; it fires waste in a plant equipped with two site-erected waterwall incinerators, with the steam furnished to the existing steam distribution system. Waste would be shredded and ferrous-reduced at the existing Charleston County Shredder Facility. Alternative D will conserve approximately 77.7×10^{10} Btu/year of fossil fuel. Based on a cost of $3.00/ton for RDF, the SIR is 1.86 and the payback is 5.5 years. The capital investment is $14,040,000 (FY82 dollars).

RECOMMENDATIONS

The Navy should determine the willingness of Charleston County to deliver shredded waste (RDF) to the proposed facility. The cost per ton of the RDF should be mutually determined; the project should be economically viable if the RDF cost is less than $15.31/ton (FY82 dollars).

If the discussions with Charleston County result in agreement, then the Navy should build a resource-recovery facility to produce steam from RDF at the Charleston Naval Shipyard Complex. The facility should consist of two field-erected waterwall incinerators, each capable of producing 75,000 lb steam/hour.

If the discussions are not productive, Federal facilities in the Charleston SMSA should continue with their present practice of disposing of waste at county-operated facilities.

FOREWORD

This study was performed by the U.S. Army Construction Engineering Research Laboratory (CERL) for the Southern Division, U.S. Navy Facilities Engineering Command, under Military Interdepartmental Procurement Request N62467-77-MP-00005. The Project Engineer for the Southern Division was Mr. R. J. Sample.

The CERL staff involved in the study were Mr. S. A. Hathaway (Principal Investigator) and Mr. A. N. Collishaw (Mechanical Engineer) of the Energy and Habitability Division (EH). Mr. R. G. Donaghy is Chief of EH.

COL J. E. Hays is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

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ENERGY RECOVERY FROM SOLID WASTE IN THE CHARLESTON, SC, SMSA

1 INTRODUCTION

Background

Department of Defense (DOD) Directive 4165.60[3] requires that studies be made to determine the feasibility of establishing single resource-recovery facilities within certain Standard Metropolitan Statistical Areas (SMSAs) of the United States. The Navy was the Federal Agency responsible for conducting the study of the Charleston SC, SMSA; the study was initiated by the Southern Division, Naval Facilities Engineering Command, at Charleston, SC.

The Federal facilities within the Charleston, SC, SMSA include the Charleston Naval Shipyard Complex (including the Naval Station and Naval Supply Center), Charleston Air Force Base; the Naval Weapons Station (and Polaris Missile Facility); the Veterans Administration (VA) Hospital; the Naval Regional Medical Center; the Charleston Army Depot; the U.S. Coast Guard; and the General Services Administration. The locations of these facilities are shown in Figure 1.

Objective

The objective of this study was to determine the technical and economic feasibility of resource recovery (both of energy and materials) at a single resource-recovery facility in the Charleston, SC, SMSA. Two types of resource-recovery facilities were considered: (1) a Federal resource-recovery facility which would use solid waste from Federal facilities only and (2) a regional resource-recovery facility which would use processed solid waste generated from both the civilian community and Federal facilities.

Approach

This study comprised several steps:

1. A meeting with representatives of the Federal facilities to explain the requirement for the feasibility study and to request the assistance of the agencies in supplying the required data for the study.

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3 *Solid Waste Management Collection, Disposal, Resource Recovery and Recycling Program*, DOD Directive 4165.60 (DOD, October 1976).

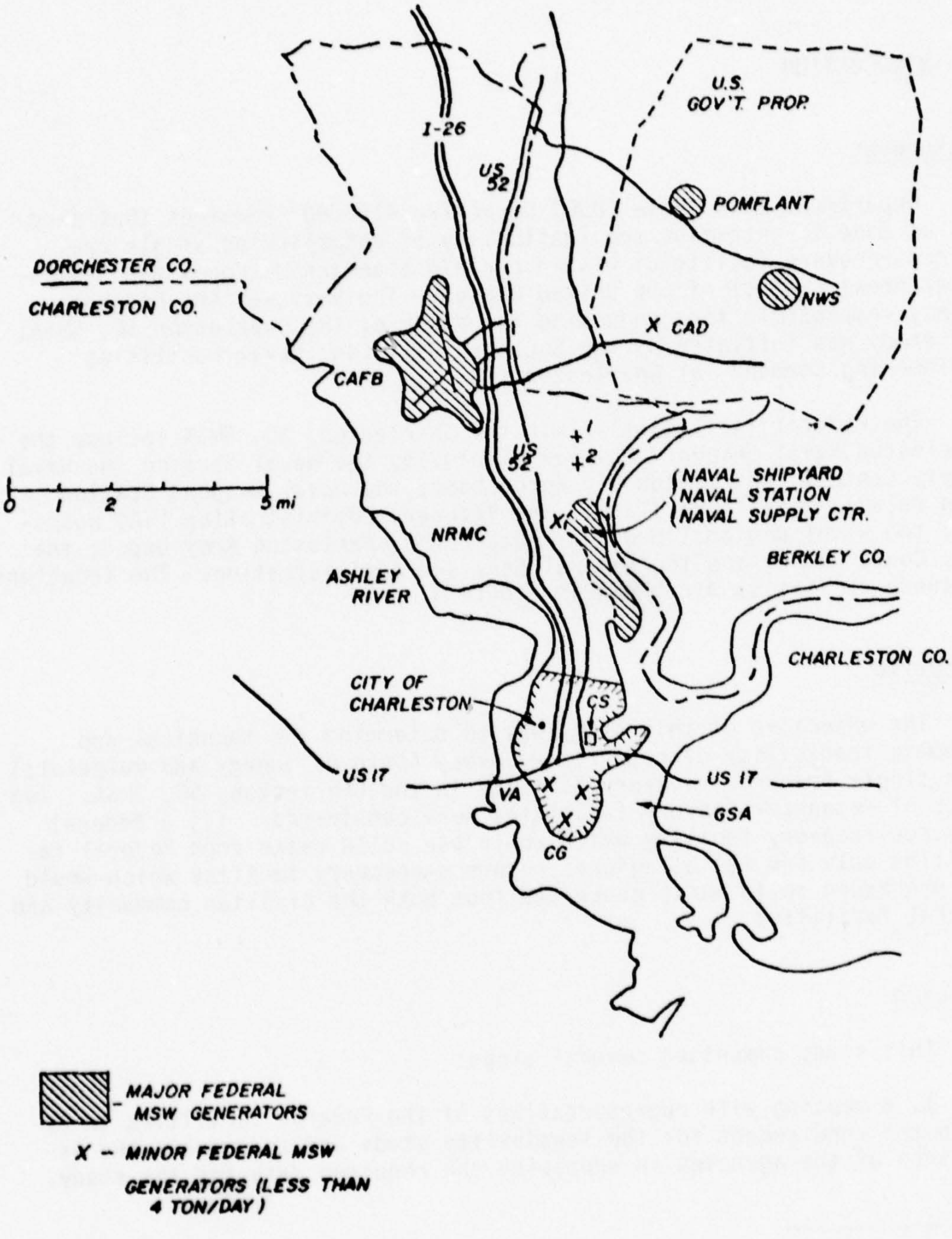

Figure 1. Federal Facilities in the Charleston, SC, SMSA.

2. A meeting th representatives of the Charleston County Health Department to disc preparations for the study and to consider possible interaction wi the existing Charleston County Shredder Facility (CCSF).

3. Data collection on energy loads, waste generation rates, and waste collection and disposal costs from the participating Federal agencies.

4. A review of resource-recovery technologies, such as refused-derived fuel (RDF) production, energy-recovery incineration, pyrolysis, and biological conversion which could be applicable to the Charleston, SC, SMSA.

5. The technologies determined applicable were then ranked and one technology selected for economic analysis.

6. Three alternative methods of implementing the chosen technology were devised.

7. Economic analyses were performed on the three alternatives plus a fourth alternative which represented the status quo; the alternative with the highest savings investment ratio (SIR) was then recommended for implementation.

2 DESCRIPTION OF PRESENT OPERATIONS

This section describes the present operation of:

1. Federal solid waste collection and disposal practice.

2. Heating systems and steam load, including the Building 32 heat distribution system at the Naval Shipyard Complex.

3. CCSF.

Present Federal Solid Waste Collection and Disposal Practice

Each Federal facility in the Charleston SMSA is responsible for managing its own solid waste collection. Each facility's solid waste generation rates and annual cost of waste collection and disposal are listed in Table 1; data were supplied by the respective facilities. The energy available from the solid waste is given in Table 2. The energy available from the solid waste generated by the Charleston SMSA installations was calculated by multiplying the quantity of waste by the heat value of the particular waste stream (Table 2). Energy data for the Naval Shipyard Complex, Naval Weapons Station and Missile Facility, and the Naval Regional Medical Center were adjusted to account for future recycling of high grade office paper. Table 3 presents the transportation requirements of the existing waste disposal system at each installation. The mileage used to compute the ton-miles per year is from each facility to the CCSF.

Charleston Naval Shipyard Complex uses Government employees to collect solid waste from the facility; a contractor collects the solid waste from family housing areas. Waste is transported to CCSF for disposal. Bulky waste* is disposed of at a "bulky landfill" designated by Charleston County.

The Naval Weapons Station and Missile Facility employs a contractor to collect and transport its waste to the Berkeley County landfill at Monk's Corner, SC.

Other Federal facilities, including Charleston Air Force Base, the VA Hospital, the Naval Regional Medical Center, Charleston Army Depot, Coast Guard, and the General Services Administration all employ contractors for waste collection and transportation. CCSF is the disposal point.

*Bulky waste, as used here, is waste specified by the management of CCSF as not acceptable to their shredder facility.

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Table 1

Mixed Solid Waste (MSW) Quantities, Collection and Disposal Costs

	Installation	Government Resource or Contractor	Data Source*	MSW (tons/yr)	MSW (tons/day+)	Annual Cost, $
1a.	Naval Shipyard Complex (to CCSF)	GR	WR	9942	38.2	360,660
b.	Naval Shipyard Complex (to landfill)	GR	FR	5003	19.2	included
c.	Naval Shipyard Complex family housing	C	BP	1946	7.6	30,000
2	Charleston Air Force Base	C	WR	6032	23.2	118,755
3	Naval Weapons Station and Missile Facility	C	WR	4056	15.6	163,100
4	VA Hospital	C	CE	832	3.2	9,300
5	Naval Regional Medical Center	C	CE	780	3.0	9,800
6	Charleston Army Depot	C	AE	450	1.8	5,415
7	Coast Guard	C	AE	320	1.2	3,800
8	General Services Administration	C	AE	290	1.1	3,500
	Totals			29,681	114.1	$704,330

* Data Source Key
WR - Weight Records, 3 months or longer
FR - Fiscal Records
BP - Based on Population
CE - Contractor Estimate
AE - Author Estimate, based on contract cost

\+ Based on 260 days/yr

Table 2

Energy Available from Federal Waste Stream - Annual Basis

Federal Installation	Solid Waste (ton/yr)	Data* Key	Energy Available (Btu/yr) x 10^{10}
Naval Shipyard Complex (to CCSF)	9,942	A	13.33†
Naval Shipyard Complex (to landfill)	(5,003)+	N.A.	- 0 -
Naval Shipyard, Family Housing	1,976	A	1.75
Charleston Air Force Base	6,032	B	7.46
Naval Weapons Station & Missile Facility	4,056	C	3.90†
Naval Regional Medical Center	780	D	0.89†
Charleston Army Depot	450	D	0.65
Subtotals	23,236		27.98
VA Hospital	832	D	1.03
Coast Guard	320	D	0.40
General Services Administration	290	D	0.42
Subtotals	1,892		1.85
Totals	24,678		29.83

*Key to sources of unit heat value data

A: Hathaway, S.A. and A.N. Collishaw, *Energy Recovery from Solid Waste at Naval Shipyard, Charleston, SC*, Technical Report E-100 (March 1977).
B: Estimated by authors to be same as A above, based on visual classification.
C: *Engineering Analysis of Solid Waste Collection, Disposal, and Resource Recovery Systems for the Naval Weapons Station, Charleston, SC* (Engineering-Science Inc., September 1976).
D: Usually estimated.

+This tonnage is not included in the totals. It is bulky waste hauled to a special county landfill area for disposal because it is technically infeasible to shred it at CCSF. This material will not be available as an energy resource in any sytem using existing county shredding capabilities.

†Included a reduction to correct for future recycling of high grade office paper.

Table 3

Transportation Data of Present
MSW Disposal System

Installation	Ton-miles* /yr
Naval Shipyard Complex	83,400
Charleston Air Force Base	66,400
Naval Weapons Station and Missile Facility	56,800
VA Hospital	1,660
Naval Regional Medical Center	4,680
Charleston Army Depot	5,400
Coast Guard	640
General Services Administration	580

* This data represents the one-way distance multiplied by the annual load carried.

Existing Federal Heating Systems and Steam Loads

Charleston SMSA Federal facilities were surveyed to determine an energy market (load) for the 29 x 10^{10} Btu/year (Table 2) available from Federally generated waste. The survey indicated that there are three major Federal energy loads in the Charleston, SC area: the Air Force Base, the Naval Weapons Station and Missile Facility, and the Naval Shipyard Complex.

Charleston Air Force Base is a large energy user; its need, however, is not consistent throughout the year, as it has a low summer load.[4] Therefore only a fraction of the energy recovered from waste could be utilized by this facility.

The Naval Weapons Station and Missile Facility's Building 316 has an energy load of only 3.26 x 10^{10} Btu/year;[5] since this is significantly less than the estimated 29 x 10^{10} Btu/year from a resource-recovery facility, it is not considered a viable load.

The Naval Shipyard Complex Boiler Plants 32, 123, NS2, and 44 have a combined load of 119 x 10^{10} Btu/year.[6] With 29 x 10^{10} Btu/year available from waste, the Naval Shipyard Complex is a viable steam load.

The Building 32 heat distribution system has the largest capacity of all the Naval Shipyard Complex boiler plants. It has five coal-fired boilers. The Complex has several other boiler plants of special interest: Buildings 123, NS2, NS44, and Bachelor Officer Quarters (BOQs) 5 and 6. These are smaller, oil fired, and are located in the South Yard of the Complex. The Navy has a project in the planning and budgeting stage to install a steam line to connect Building 32 to the distribution lines of the boiler plants at Buildings 123, NS2, NS44, and BOQs 5 and 6. While construction has not begun at this writing, for the purpose of this study the steam line is considered as existing. The phrase "Building 32 system" used hereafter refers to the Building 32 system as extended to the South Yard of the Complex which serves Buildings 32,

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4 Personal communication with Mr. L. H. Manseau, Chief, Engineering and Construction, 437 Civil Engineering Squadron, Charleston AFB, 27 April 1977.

5 Calculated from 2 years of load data presented in *Engineering Analysis of Solid Waste Collection, Disposal, and Resource Recovery Systems for Naval Weapons Station, Charleston, SC* (Engineering Sciences, Inc. 1976), pp VI-2.

6 Calculated from 2 years of load data presented in *Energy Study for U.S. Naval Shipyard at Charleston, SC* (R. S. Noonan, Inc., April 1976), p A13.

123, NS2, NS44, and BOQs 5 and 6. Figure 2 illustrates the steam load of the Building 32 system.

For 10 months of the year, the coal-fired boilers of Building 32 meet the steam demand on the Building 32 system. For 2 months, the oil-fired boilers of Building 123 are used to meet the peak loads. This means that both coal and oil are used to meet the steam demand on the Building 32 system.

CCSF

Charleston County, SC, has been operating a shredder facility since June 1974. CCSF's equipment includes two 20 tons/hour and one 40 tons/hour shredders; a magnet system in the processing line removes ferrous metals from the shredded waste. All mixed solid waste (MSW) generated in the civilian community and at Federal facilities in Charleston County is taken either to the CCSF or a designated "bulky landfill." In a recent 12-month period, 138,000 tons of MSW were hauled to CCSF. The average MSW was 11,440 tons/month, the maximum was 16,390 tons/month, and the minimum was 9,290 tons/month. The county is landfilling the shredded waste adjacent to CCSF.

In discussions with local and state representatives,[7] it was learned that the present landfill is near capacity and will soon close. The representatives estimate that the one-way haul to the new landfill, when it is established, will exceed 20 miles. The county has indicated interest in methods to reduce the weight and volume of material to be landfilled. One such method is energy-recovery incineration. At this time, the only resource being recovered at CCSF is ferrous metal. The potential exists for recovering energy from the waste shredded at CCSF. Figure 2 shows the estimated amount of steam available to the Naval Shipyard Complex Building 32 system if a resource-recovery facility were established at the Complex and if CCSF shredded waste were incinerated there.

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[7] Personal communication with Mr. J. D. Ohlandt, Regional Solid Waste Consultant to the South Carolina Department of Health and Environmental Control and Mr. L. Singletary, Manager of CCSF, 25 April 1977.

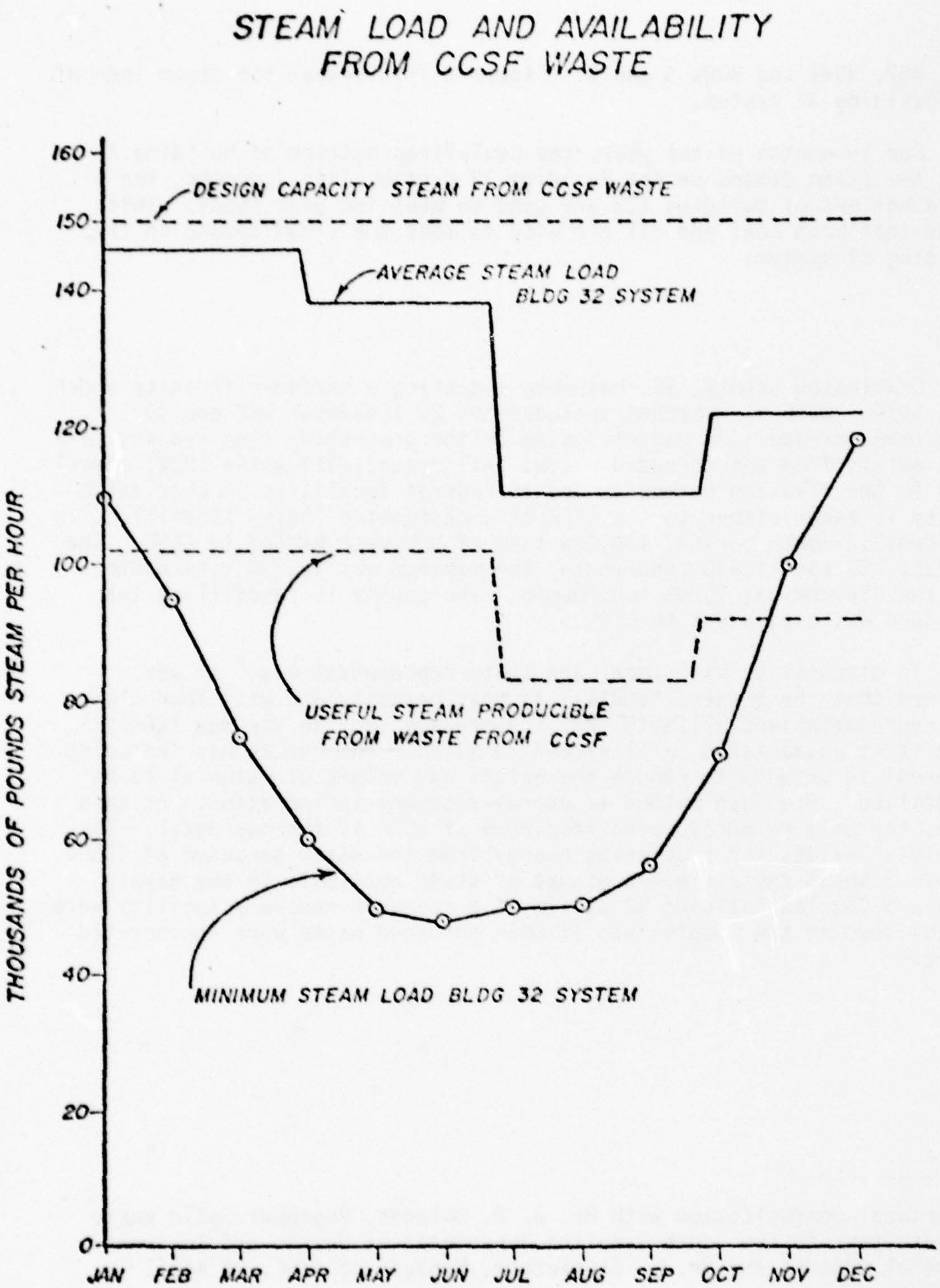

Figure 2. Steam load of Building 32 system.

3 TECHNOLOGY SELECTION

This investigation employed a three-step evaluation procedure to reveal the most viable of commercially available resource-recovery technologies. The procedure has been developed and used elsewhere to support resource-recovery feasibility studies both for large muncipalities and military installations.[8,9,10] The essential steps of the procedure are as follows:

1. Evaluate commercial technologies for their capability to meet overall general goals of the needed resource-recovery system. Eliminate those which do not.

2. Evaluate specific processes within goal-compatible technologies to determine whether they will provide sound engineering solutions and determine if all processes will be available within the current MILCON 5-year construction cycle. Eliminate unavailable or unacceptable processes.

3. Evaluate goal-compatible, available processes using a weighted comparative scoring system to reveal which is the relatively superior process. Implement the top-ranked process in the proposed resource-recovery facility.

Step 1: General Goal Evaluation

The following general goals were to be accomplished by an acceptable resource-recovery technology.

1. Maximize waste processing in order to minimize landfill requirements.

2. Maximize resource recovery (materials and energy) within the constraints of the local market.

3. Minimize the amount of processing necessary before solid waste can be used as fuel in the resource-recovery facility in order to gain maximum economic credit for its recovered value.

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8 *Refuse Incineration/Heat Reclamation Boiler Facility, Naval Station, Mayport, FL* (Greenleaf/Telesca, 1975).

9 Cho, P. and Sanneman, *Supplemental Fuel Processing Plant for Chicago, IL*, Proceedings, Third Inter-University Engery Conference (1976).

10 Hathaway, S. A. "Evaluation of Small Scale Waste-to-Energy Systems," *Proceedings of the Third International Conference on Environmental Problems of the Extractive Industries*, F. Rolsten and P. Sweeney, eds. (The Wright Corporation, 1977).

4. Minimize the land area required for the process equipment and facility.

Five technologies were evaluated in light of these overall goals. Table 4 defines these technologies. As a result of the evaluation carried out under Step 1, simple materials separation and biological conversion were eliminated. The materials separation technology was found not to reduce waste bulk to acceptable levels, and to make incomplete use of waste as a resource by neglecting its energy value. In addition, the technology required significantly high capital investment. This cost plus the operating costs made the technology's expense relative to the market value of the separated materials (e.g., metals and glass) unacceptable. Biological conversion was eliminated because substantial land area is required for the individual processes, and substantial quantities of byproduct materials remain a landfill requirement. Technologies retained for further consideration in the evaluation process were production and use of RDF, pyrolysis, and energy-recovery incineration.

Step 2: Process Availability Analysis

This investigation defined a process as being available if there was reasonable expectation that it could be presented as a sound engineering solution within the current MILCON cycle of 5 years. Thus a process presently nearing commercial availability could be retained although it might not be ready for immediate implementation. Tables 5, 6, and 7 summarize the processes which were evaluated for RDF production and use, energy-recovery incineration, and pyrolysis, respectively.

The processes which were found to be available included the Union Carbide Purox pyrolysis process, direct combustion in a waterwall incinerator (energy-recovery incineration) and use of pelleted, or densified, RDF. Package heat-recovery incineration processes were eliminated because they are too small for application on the scale this study required. Many pyrolytic conversion systems were eliminated because they were still in the preliminary developmental stage and would not be ready for use within the current MILCON cycle. Of the RDF processes evaluated, only densified RDF was retained because it is fired with coal by mechanical stokers, the same system with which the Central Power Plant (Building 32) at the Naval Shipyard Complex is equipped. Although suspension-fired unconsolidated, or "fluff", RDF has been successfully demonstrated in St. Louis, MO, and Ames, IA,[11] these were utility-type boilers of a scale much larger than the furnaces at the Complex. Complex boilers would require significant modification -- tantamount to a

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11 *Report on Status of Technology in the Recovery of Resources From Solid Wastes* (County Sanitation Districts of Los Angeles, 1976), pp 29 to 39.

Table 4

Evaluation of Energy/Materials Recovery Technologies

PROCESS	DESCRIPTION
RDF production	Solid waste processed to a solid fuel for supplementary firing in existing steam generators
Energy-recovery incineration	As-delivered or processed solid waste fired in incinerator equipped with heat-recovery/steam generating hardware
Pyrolysis	Conversion of as-delivered or processed solid waste to a low-Btu gaseous or liquid fuel for supplementary firing in existing steam generators
Biological conversion	Capture and use of low-Btu gas from biological degradation of solid waste (anaerobic digestion, composting, landfill gas recovery).

Table 5

Review of Energy-Recovery Incineration Processes

Location	Principal	Design Capacity (tons/day)	Status
Baltimore, MA	Monsanto Enviro-Chem Systems	1000	Shakedown
Blythesville, AR	City	50	Operational, 1974
Chicago, IL	City of Chicago	1600	Operational, 1972
Dade County, FL	City	200	Shakedown
East Hamilton, Ontario, CAN	Municipality	600	Operational
Ft. Eustis, VA	U.S. Army	406	Concept
Hempstead, NY	Parsons & Whittemore	2000	Construction
Harrisburg, PA	City Incinerator Authority	720	Operational, 1972
Jacksonville, FL	U.S. Navy	20	Design
Menlo Park, CA	Combustion Power Co.	100	Demonstration
Midland, MI	Dow Chemical Co.	60	Operational, 1974
Nashville, TN	Nashville Thermal Transfer Corp	720	Shakedown
Norfolk, VA	U.S. Navy	120	Operational, 1967
North Little Rock, AR	City	100	Construction
Orchard Park, NY	Carborundum Comp-Torrax Div.	75	Demonstration

Table 6

Review of RDF Production Processes

Location	Principal	Design Capacity (tons/day)	Status
Akron, OH	Glaus, Pyle, Schomer, Burns & DeHaven	1000	Construction
Ames, IA	Gibbs, Hill, Durham & Richardson	500	Shakedown
Baltimore, MD	TELEDYNE	1000	Operational 1976
Berlin, CN	Combustion Equipment Assoc.	1400	Design
Bridgeport, CN	Occidental Research Corp	1500	Design
Chicago, IL	Ralph Parsons/Consoer/Townsend & Assoc.	2000	Construction
Ft. Monmouth, NJ	U.S. Army	60	Design
Los Gatos, CA	Vista Chemical & Fibre	500	Operational 1973
Milwaukee, WI	American Can Co.	1000	Construction
Oak Ridge, TN	Tennessee Valley Authority	1000	Concept
St. Louis, MO	Union Electric Co.	315	Demonstration 1972
Santa Rosa, CA	Waste Control Science	NA	Concept
Portsmouth, VA	U.S. Navy	100	Shakedown
Quebec, CAN	City	1000	Operational, 1974
Rochester, NY	Eastman Kodak	50	Operational, 1975
Saugus, MA	Refuse Energy Systems Co.	1200	Operational, 1976
Washington, DC	Department of Defense (Pentagon)	20	Operational, 1977

Table 7

Review of Pyrolytic Conversion Processes

Location	Principal	Design Capacity (tons/day)	Status
El Cajon, CA	Occidental Research Corp.	200	Construction
Irvine, CA	Barber-Colman Co.	1	Pilot
Lancaster, CA	Ecology Recycling Unlimited	10	Pilot
Riverside, CA	Pyrolysis Systems, Inc.	50	Design
Upland, CA	Pan American Resources	4	Pilot
Santa Ana, CA	Enterprise Co.	0.5	Pilot
Santa Barbara, CA	Kemp Reduction Corp.	0.5	Pilot
South Charleston, WV	Union Carbide Corp.	200	Advanced development

complete rebuilding -- to acquire the capability to suspension fire a waste fuel having a calorific value approximately half that of coal.

Step 3: Comparative Scoring System

The comparative scoring system used to reveal the most successful candidate process followed five major steps.

1. Six criteria were established against which each candidate process was evaluated. These criteria are listed and described under Step 3-1 below.

2. For each of the six criteria, a relative importance weight was assigned in consultation with personnel familiar with the site.

3. Each process was given a relative raw score for each criterion.

4. The relative raw score of each process was weighted by the relative importance factor established for each criterion.

5. Weighted relative scores were summed and normalized, with the process having the highest score chosen for application.

Step 3-1: Definition of Criteria

Six criteria were established for evaluating candidate technologies:

1. Technical reliability
2. Practicability
3. Conservation
4. Environmental impact
5. Experience
6. Economics.

Technical reliability refers to the chance of unforeseen outage and the predictability of dependable performance. It is a measure of both the degree to which a design incorporates *proven configurations* and of the potential of the system's design to withstand predictable wear.

Practicability refers to the feasibility of operating and managing a system within the support capabilities at a specific site. It is measurable in terms of the degree of a system's complexity (a complex system which would make its performance contingent upon skilled personnel), the ease of performing routine daily and cyclic maintenance and repair (including procurement, installation, and shakedown of replacement parts), and the degree to which the function of a resource-recovery

system will affect management: transportation, processing, marketing, and ultimate disposal.

Conservation refers to the efficiency with which a system uses resources and the degree to which a system reuses or recaptures *energy* (power and fuel), *materials* and *water*, or the extent to which a system consumes additional resources.

Environmental impact refers to the impact of the system on the immediate *air*, *water*, and *land* environments. This is the effects of atmospheric emissions, requirements for water effluent treatment, and landfill disposal of system byproducts; consideration is given to the environmental impact if pollution abatement equipment suffers transient failure. Compatability with the environment also includes the degree to which a system is a *nuisance*, i.e., its impact as measured in terms of traffic increases and/or interference, odor, unsightliness, noise, and vibration.

Experience is the critical basis for predicting and guaranteeing the life-cycle performance of a system with reasonable accuracy. It is expressable as an *operational history* of the combined use of similar equipment for resource recovery at or near the scale of application that the site requires. It also considers the number of facilities of similar design presently in operation.

Economics is linked to experience and technical reliability in that it gives a basis for an accurate estimate of a system's recurring costs and the length of its functional life. Economics is measurable in terms of initial costs: including investment for equipment and facility implementation expenses for startup, field alignment, and operator training. Second, it is measurable in terms of the recurring (annual and cyclic) costs of operating and maintaining a system.

Step 3-2. Assignment of Relative Importance Factor

A relative importance factor was assigned to each criterion in consultation with Complex and NAVFACSOUTHDIV personnel. The factors ranged from 0 to 1 depending on the degree of relative importance, with 1 being the most important process attribute. The related importance factors used are as follows:

1. Practicability (1.00)
2. Economics (0.90)
3. Technical reliability (0.70)
4. Conservation (0.70)
5. Experience (0.70)
6. Environmental impact (0.40).

Step 3-3: Process Raw Scores

Table 8 shows the relative raw scores assigned to each of the processes evaluated. The scores were assigned to as many as four subcategories under each of the step criteria. The subcategories shown in Table 8 are defined in Step 3-1. A relative score was given to each subcategory so that the row sum equaled 10, a number which was arbitrarily chosen to obtain a reasonable spread of scores. For each criterion, a score was obtained by adding appropriate subcategory scores.

Step 3-4: Process Weighted Scores

Table 9 shows the results of adjusting process raw scores by the relative importance factors. A weighting factor was used to adjust the scores by accounting for a variable number of criteria subcategories. The process weighted scores shown in Table 9 represent the process raw scores for each criterion in Table 8 as adjusted by the weighting factor and relative importance factor.

Step 3-5: Process Selection

Selection of the relatively superior process was made by summing process scores shown in Table 8. As indicated in Table 9, the waterwall incinerator achieved the highest score -- of 40.0. On a normalized basis, this score is 1.0. The normalized score of the Purox pyrolysis system was calculated to be 0.80, and that of densified RDF 0.41. On the basis of the normalized score, the waterwall incinerator was selected as the candidate process for consideration in this investigation.

Table 8

Process Raw Scores

	Waterwall Incinerator	Purox Pyrolysis	Densified RDF	Row Sum
Technical Reliability				
Proven art	5	3	2	10
Predictable wear	5	3	2	10
Subtotal	10	6	4	
Practicability				
Complexity	5	4	1	10
Maintenance and repair	4	4	2	10
Management impact	4	5	1	10
Subtotal	13	13	4	
Conservation				
Energy	5	3	2	10
Materials	3	3	4	10
Water	3	3	4	10
Subtotal	11	9	10	
Environment				
Air	3	5	2	10
Water	3	3	4	10
Land	4	4	2	10
Nuisance	3	4	3	10
Subtotal	13	16	11	
Experience				
Operational history	7	2	1	10
Number of facilities	5	3	2	10
Subtotal	12	5	3	
Economics				
First costs	4	5	1	10
Recurring costs	5	4	1	10
Subtotal	9	9	2	

Table 9

Weighted Process Scores

Category	Weighting Factor (WF)	Importance Factor (IF)	Process Weighted Scores* Waterwall Incinerator	Purox Pyrolysis	Densified RDF
Technical reliability	1.00	0.70	7.0	4.2	2.8
Practicability	0.67	1.00	8.7	8.7	2.7
Conservation	0.67	0.70	5.2	4.2	4.7
Environment	0.50	0.40	2.6	3.2	2.2
Experience	1.00	0.70	8.4	3.5	2.1
Economics	1.00	0.90	8.1	8.1	1.8
Total			40.0	31.9	16.3
Normalized score			1.00	0.80	0.41

*/Weighted score = Raw subtotal score x WF x IF

4 DESCRIPTIONS AND ECONOMIC ANALYSES OF ALTERNATIVES

The four alternatives evaluated during this study were selected based on the objectives of the study and the evaluation of technologies described in Chapter 3.

1. Alternative A: the present practice of disposing of MSW at county facilities.

2. Alternative B: a Federal resource-recovery facility at Charleston Naval Shipyard Complex, which processes and recovers energy from Federal waste only.

3. Alternative C: a regional resource-recovery facility, Level I -- operation at 69,900 tons/year of Federal and civilian solid waste from CCSF.

4. Alternative D: a regional resource-recovery facility, Level II -- operation at 86,800 tons/year of Federal and civilian solid waste from CCSF.

Table 10 compares the major characteristics of each alternative. The process flow of each alternative is shown in Figure 3.

This chapter describes the economic analysis of the four alternatives described above. The capital investment required for each alternative and the present value (PV) cost (or savings) of operating each alternative over 25 years are presented along with a comparison of these costs. The details of the analysis procedure are given in Appendix A. The unit costs of utilities, material, short-term inflation multipliers, and long-term differential escalation rates and multipliers are defined or developed in Appendix A.

Alternative A, Present Practice

The 25-year collection and disposal costs for continuing the present practice of using the county facilities for the disposal (without resource recovery) of Federal waste are $9,875,400 (Table 11). Note that there is an estimated increase of 50 percent in the dump fee above the increase due to inflation; this increase accounts for the estimated cost of establishing a new landfill. The present landfill used by Charleston County is adjacent to the shredder facility. Charleston County health officials anticipate that the present landfill will soon be at capacity and that the new landfill will be at least 20 miles from the present site. Since no significant Federal capital investment is involved in continuing the practice, Alternative A serves as a baseline to compare with the other alternatives.

Table 10

Characteristics of Resource-Recovery Alternatives

Alter-native	Description of Alternative System	Solid Waste (tons/yr)	System Operations (hrs/day and days/wk)	Design Capacity (lb steam/hr)	Lb Steam/yr From Waste	Percent of Annual Steam Requirement*
A	Present practice. Dispose of Federally generated waste at landfills operated by counties.	29,700 (Federal Waste)	--	0	0	0
B	Federal resource-recovery facility at Charleston Naval Shipyard Complex producing steam from waste generated by Federal facilities.	23,000	15 hrs 5 days	60,000	180	16
C	Regional resource-recovery facility, Level I at Charleston Naval Shipyard complex producing steam from Federal and civilian waste. Waste shredded (producing RDF) at existing Charleston County Shredder Facility.	69,900	15 hrs 6 days	160,000	455	41
D	Regional resource-recovery facility, Level II, as above, except larger annual capacity.	86,800	24 hrs 5 days	150,000	565	50

*Note: The percent is of the major steam load of Charleston Naval Shipyard Complex, presently served by Boiler Plants 32, 123, NS2 and NS44, and BOQs 5 and 6.

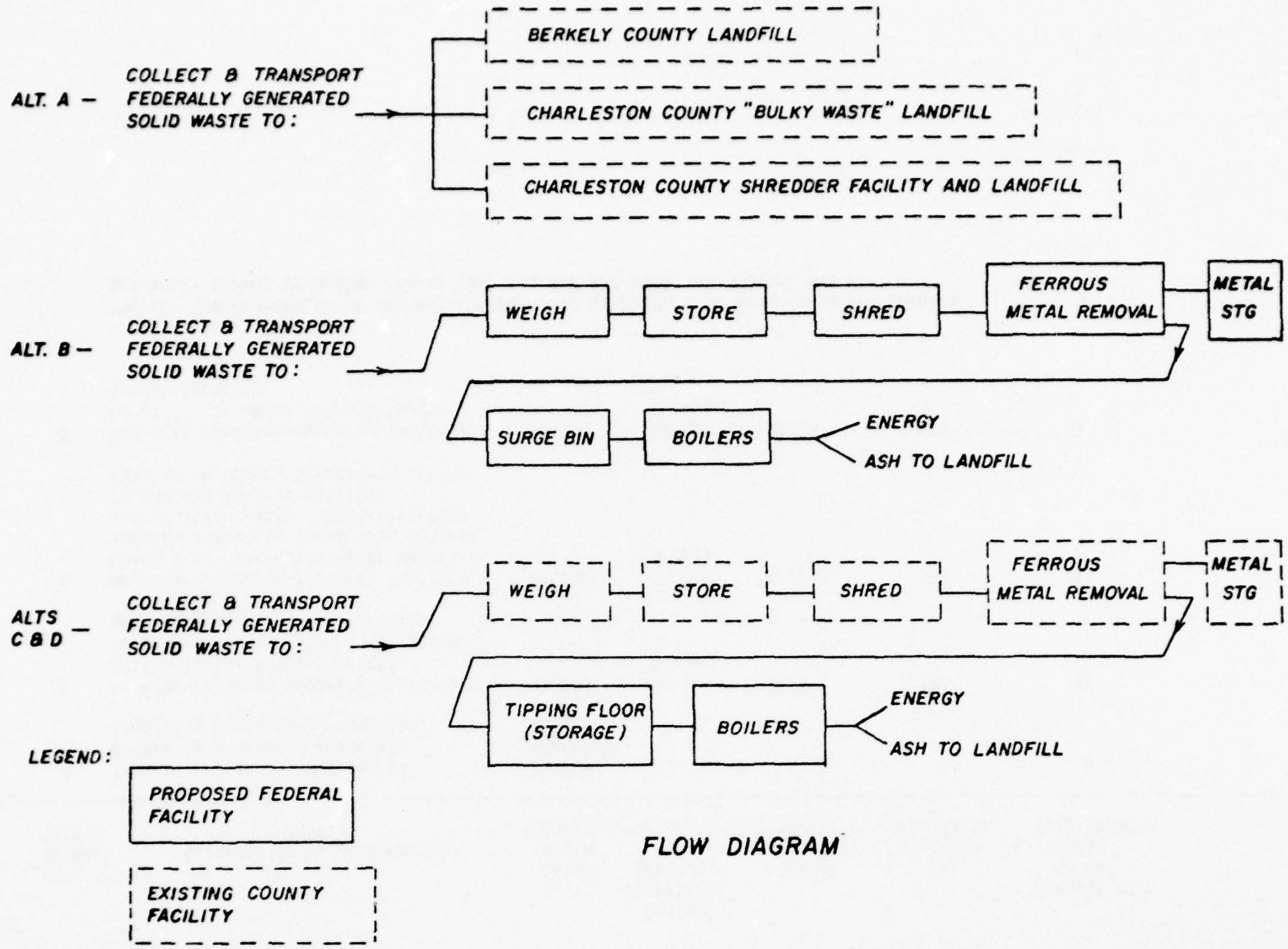

Figure 3. Process flow of Alternatives A through D.

Table 11

25-Year Solid Waste Collection and Disposal Costs of Alternatives A through D

Federal Facility	Costs ($1000) Alternative A	Alternative B*	Alternatives C & D
Navy Shipyard Complex	$ 390.6	324	390.6
Air Force Base	118.8	85	118.8
Naval Weapons Station	163.1	150	163.1
Naval Regional Medical Center	9.8	9.3	9.8
Charleston Army Depot	5.4	5.1	5.4
FY77 Subtotals	687.1	573.4	687.1
Short-term inflation multiplier	x1.37+	x1.37	x1.37
	941.3	785.6	943.1
Additional cost due to new landfill	+95.6†	19.1	+61.5
FY82 estimated costs	$1036.9	804.7	1,004.6
25-yr PV multiplier	x9.524+	x9.524	x9.524
25-year PV cost	$9875.4	$7664.0	$9567.8

* The reductions of Alternative B are due to savings in dump fees and haulage distances.

+ The short-term inflation multiplier and the 25-year present value multiplier are defined in Appendix B.

† It is estimated that the dump fee will increase by 50% when a new landfill is opened.

Conditions Common to Resource-Recovery Alternatives B, C, and D

The energy produced by these alternatives would supplement the existing coal-fired Building 32 heat-distribution system. A steam line would connect the output of the resource-recovery facility to the Building 32 system near the intersection of Halsey Street and Hobson Avenue. The Building 32 system serves the areas of Buildings 32, 123, NS2, and 44, and BOQs 5 and 6. Since coal-fired Building 32 cannot handle the peak loads on its expanded system, some of the energy credits produced by Alternatives C and D will be in fuel oil. Oil-fired Building 123 will not be needed to handle peak loads except when the regional resource-recovery facility (Alternatives C or D) is off-line, such as on weekends or during unscheduled outages.

The proposed site for a resource-recovery facility at the Charleston Naval Shipyard Complex is the same for all resource-recovery alternatives (see Appendix C). The Complex has designed and anticipates the construction of a refuse segregation, holding, and processing facility to be located south of Bainbridge Avenue and west of Halsey Street extension. The site for each alternative would be south and adjacent to the refuse segregation, holding, and processing facility. The site, which has been coordinated with Public Works personnel at the Complex, is swampy in nature and requires the use of pile foundations. The costs of the foundations and other special construction requirements are included in the estimate of the capital investment for each alternative.

Alternative B, Federal Resource-Recovery Facility

This alternative is a facility proposed to be built on the Charleston Naval Shipyard Complex. It is designed to handle the 23,240 tons/year of solid waste generated only by participating Federal facilities (see Appendix C). The waste from the participating facilities would be collected and hauled to the Complex, where it would be processed two shifts/day, 5 days/week. Note that, if three shifts/day are used, time available for maintenance would be reduced and the labor costs would be increased. Higher life-cycle labor costs do not effectively trade off with the very small reduction in plant size and investment cost.

For the economic analysis, it is estimated that the system will be down for scheduled maintenance 10 days/year and down for unscheduled maintenance 5 days/year. Therefore, the system will be available for 245 days of the normal 260-day work year. Waste would be stored on the

tipping floor until needed for processing. Each half of the tipping floor will hold 75 percent of a normal day's waste. A front-end loader would move the waste from the tipping floor to one of the two conveyor pits. (Two each of conveyor pits, conveyors, shredders, and front-end loaders will provide redundancy for the system.) The waste will be shredded as it is needed, and ferrous metals will be removed prior to burning in the two 30,000 lb/hour steam boilers which will operate at 160 psig and 420°F. Alternative B would produce 16 percent of the annual steam load of the Building 32 system or 179.2×10^6 lb steam/year (19.0×10^{10} Btu/year). It is estimated that the system will conserve 10,000 tons of coal/year. The process flow for the proposed facilities is shown in Figure 3.

The capital investment required is $8,500,000 (Table 12). The 25-year PV of the annual costs is $14,016,000. PV credits are $11,035,000 (Table 13).

Alternative C, Regional Resource-Recovery Facility, Level I

This alternative, regional resource-recovery facility, Level I, is designed to accommodate 69,900 tons/year of shredded RDF purchased from CCSF. In this alternative, all of the Federal waste -- with the exception of that generated at the Naval Weapons Station, which would continue to be landfilled at the Berkeley County landfill* -- is hauled to CCSF for processing, as is the present practice. The 69,900 tons/year amount to 50 percent of the RDF presently produced at CCSF. RDF not sold to the Navy will be landfilled, as is the present practice.

CCSF personnel will deliver the RDF to the Complex on an "as needed" basis. This will range from 190 tons/day in the summer to 250 tons/day in the winter. RDF will be burned two shifts/day, 6 days/week. A third shift will be used for boiler clean-out and minor maintenance. For the economic analysis, it is estimated that the system will be down for scheduled maintenance 12 days/year and unscheduled maintenance 6 days/year; thus it will be available 294 days/year. There would be two 80,000 lb/hour boilers. The amount of steam produced from RDF with this alternative is 455.5×10^6 lb steam/year (or 48.2×10^{10} Btu/year). (See Appendix D, Table D1.) This represents 41 percent of the annual steam load of the Building 32 system. It would conserve 23,900 tons of coal/year and 260,000 gallons of fuel oil.

*See Appendix C.

Table 12

Alternative B: Investment Cost

Item	Quantity	Unit Cost ($1000)	Cost ($1000)
Scales, truck	1	20	20
Conveyor pit	2	5	10
Feed conveyor, steel belt	2	25	50
Shredder 25 ton/hr	2	125	250
Dust control	1	10	10
Outlet conveyor rubber belt	2	10	20
Magnetic metal separator	2	35	70
Surge bin	2	12	24
Conveyors to storage	4	5	20
Boiler 30,000 steam/hr	2	900	1800
Air pollution control	2	165	330
Stack & breeching	1	80	80
Ash handling	1	100	100
Special foundation (piles)	266	1.68	447
Building, 20 ft clear height	16,150 sq ft	20	323
Building, 35 ft clear height	16,100 sq ft	30	483
Building, misc site work	1 job	60	60
Electrical substation		10	10
Exterior lighting		2	2
Steam line, 18 in. dia	3750 ft	173	650
Fence	1400 ft	8.45	11.8
Road, 24 ft wide, 390 ft	1040 sq yd	12.30	12.7
Fill	5550 cu yd	2.30	12.8
			4796.3
	Multiplier to include engineering, overhead, and profit		x1.26
			6043.3
Front-end loaders	2	55.4	+110.8
	Total FY77 estimate		6154.1
	FY82 multiplier		x1.38
			8492.7
	Budget estimate		8500.

Table 13

25-Year PV Operation
And Maintenance (O&M) Cost: Alternative B

O&M Cost Elements	Quantity (1000)	Units	FY78 Unit Price	25-yr Inflation Factor	PV Cost ($1000)
Costs					
Front-end loader fuel	3.9	gal/yr	1.16	20.050	90.7
Shredder, 250 Hp	363	kWh/yr	0.055	16.303	325.5
Magnetic separator, 5 kw	20	kWh/yr	0.055	16.303	17.9
Conveyors, 25 Hp	36	kWh/yr	0.055	16.303	32.0
Boilers, 200 Hp	580	kWh/yr	0.055	16.303	520.1
Air pollution control, 25 Hp	36	kWh/yr	0.055	16.303	32.3
Ash handling, 10 Hp	4	kWh/yr	0.055	16.303	3.6
Misc building	5	kWh/yr	0.055	16.303	4.5
Boiler feed water	22000	gal/yr	.00064	9.524	134.1
Misc water	130	gal/yr	.00064	9.524	0.8
Auxiliary fuel oil (.5%)	8.6	gal/yr	0.76	20.050	131.0
Labor (Table A3)			296.0	9.524	2819.1
Maintenance (5% of Table 12)	185	$/yr	-	9.524	1762.0
Ash disposal	5.7	ton/yr	9.15	9.524	496.7
Solid waste collection (Table 11)					7664.0
					$14,016.4
		Budget estimate			$14,020
Credits					
Ferrous metal	730	ton/yr	23	9.524	160.0
Fuel (coal, Table B1)	10	ton/yr	58.31	14.777	8617.1
O&M of Bldg 32 (Table D1)	236.0	$/yr	-	9.524	2247.7
		Total credits			$11,034.6
		Budget estimate			$11,030

As previously noted, it is anticipated that oil-fired Building 123 must be maintained and operated to supply peak steam needed in the South Yard of the Complex. While the average hourly steam load supplied by Building 123 is 33,300 lb/hour, the peak load is 109,000 lb/hour. Since the capacity of Alternative C is 160,000 lb/hour, it will easily handle the peak load. Because oil-fired Building 123 will not have to be operated except on weekends and during unscheduled shutdowns, part of the fuel credit is taken in oil. It is estimated that 6 percent of the annual fuel savings will be oil; the remainder will be coal. The capital investment for Alternative C is $13,900,000 (Table 14). The 25-year PV of the annual costs is $21,990,000; the PV credits are $30,140,000 (Table 15).

Alternative D, Regional Resource-Recovery Facility, Level II

This alternative, regional resource-recovery facility, Level II, is similar to Alternative C; however, Alternative D is designed to handle 86,800 tons/year of RDF produced at CCSF (63 percent of the County's present annual production), and will operate 24 hours/day, 5 days/week. Although the 24-hours/day of Alternative D will allow more energy recovery than will Alternative C, there will be only 2 days/week available for unscheduled cleanout and minor maintenance. The 86,800 tons of RDF received at the Alternative D facility will be reduced to approximately 21,700 tons of ash/year, thus reducing landfill needs. RDF produced by CCSF and not sold to the Navy would be landfilled. There will be two boilers rated at 75,000 lb/hour at the Alternative D facility. For the economic analysis, it was assumed that there would be 15 days of downtime for scheduled maintenance per year and an additional 10 days lost to unscheduled maintenance. The system would be available for 235 days out of the normal 260-day year (90 percent available). The amount of steam produced from RDF is 565.3×10^6 lb steam/year (see Appendix B, Table B3); this will conserve 77.8×10^{10} Btu/year of fossil fuel. This represents 50 percent of the annual steam load of the Building 32 system. Alternative D would conserve 29,600 tons coal/year and 321,500 gallons of fuel oil. The fuel credit attributable to oil for this alternative is 6.2 percent. The capital investment is $14,040,000 (Table 16). The 25-year PV of the annual costs is $21,340,000; the credits are $37,510,000 (Table 17).

The potential income to Charleston County under Alternative D is $260,000/year (FY82 dollars). This income is based on a sale price of $3.00/ton of RDF (FY82 dollars, or $1.86/ton, FY77 dollars). The detailed calculations of RDF cost and income to Charleston County appear in Appendix E.

Table 14

Investment Cost:
Alternative C, Regional

ITEM	Quantity	Unit Cost ($1000)	Cost ($1000)
Conveyor pit	2	7	14.
Conveyor	2	10	20.
Boiler 80,000 lb steam/hr	2	2355	4710
Air pollution control	2	450	900
Stack & breeching	1	100	100
Ash handling	1	200	200
Steam line	3750	173	650
Special foundations (piles)	274	1.68	460
Building, 20 ft clear height	28,000	20	560
Bldg 40 ft clear height	4400	30	132
Bldg Misc site work	1 job	60	60
Electrical substation	1	12	12
Exterior lighting	1	2	2
Fence	3800 ft	8.45	32.1
Road, 24 ft wide x 1400 ft	3735 sq yd	12.30	45.9
Fill	8750 yd	2.30	20.1
			7918.1
Multiplier to include engineering, overhead, & profit			x 1.26
			9976.8
Front-end loaders	2	55.4	110.8
Total FY77 estimate			10087.6
FY82 multiplier			x 1.38
			13,920.9
Budget estimate			$13,900

Table 15

25-Year PV O&M Cost: Alternative C

O&M Cost Elements	Quantity (1000)	Units	FY82 Unit Price	25-yr Inflation Factor	PV Cost ($1000)
COSTS					
Front-end loader fuel	7.1	gal/yr	1.16	20.050	165.0
Conveyors, 20 Hp	34.8	kWh/yr	0.055	16.303	31.2
Boilers 480 Hp	1680	kWh/yr	0.055	16.303	1506.0
Air pollution control 30 Hp	54	kWh/yr	0.055	16.303	48.4
Ash handling 10 Hp	4.8	kWh/yr	0.055	16.303	4.3
Misc building	6	kWh/yr	0.055	16.303	5.4
Boiler feed water	54900	gal/yr	.00064	9.524	334.6
Misc water	360	gal/yr	.00064	9.524	2.2
Auxiliary fuel oil (.5%)	16.1	gal/yr	0.76	20.050	245.0
Labor (Table A3)	278.5	$/yr	-	9.524	2652.4
Maintenance (5% of Table 14)	372.	$/yr	-	9.524	3543.0
Ash disposal	17.5	ton/yr	9.15	9.524	1525.0
Solid waste collection (Table 11)					9568.0
RDF purchase	69.9	ton/yr	3.00	11.238	2356.6
		Total costs			$21,987.2
CREDITS		Budget estimate			$21,990.0
Fuel (coal, Table B4)	23.9	ton/yr	58.31	14.777	20,593
Fuel (oil, Table B4)	250.6	gal/yr	0.76	20.050	3,819
O&M Bldg 32 (Table B1)	601.1	$/yr	-	9.524	5725.
					30,137
		Budget estimate			$30,140

Table 16

Investment Cost:
Alternative D, Regional

Item	Quantity	Unit Cost	Cost ($1000)
Conveyor pit	2	7	14
Conveyor	2	10	20
Boiler, 75,000 lb steam/hr	2	2230	4460
Air pollution control	2	450	900
Stack & breeching	1	110	110
Ash handling	1	220	220
Steam line	3750	173	650
Special foundation (piles)	330	1.68	554
Building, 20 ft clear height	35200	20	704
Building, 40 ft clear height	6050	30	181.5
Building, misc site work	1 job	60	60
Electrical substation	1	12	12
Exterior lighting	1	2	2
Fence	3900	8.45	33
Road, 24 ft x 1400 ft	3735	12.30	45.9
Fill	9730	2.30	22.4
			7,988.8
Multiplier to include engineering, overhead & profit			x 1.26
			10,065.9
Front-end loaders	2	55.4	+ 110.8
		Total FY77 estimate	10,176.7
		FY77 to FY82 multiplier	x 1.38
			14,043.8
		Budget estimate	14,040.

Table 17

25-Year PV of O&M Costs: Alternative D

O&M Cost Element	Quantity (1000)	Units	FY82 Units Price	25-yr Infla-tion Factor	PV Cost ($1000)
COSTS					
Front-end loader fuel	9.4	gal/yr	1.16	20.050	219.0
Conveyors & ash handling 30 Hp	72.0	kWh/yr	0.055	16.303	64.6
Boiler, 400 Hp	1870.0	kWh/yr	0.055	16.303	1676.8
Air pollution control, 30 Hp	72.0	kWh/yr	0.055	16.303	64.6
Miscellaneous building	8.0	kWh/yr	0.055	16.303	7.2
Boiler feed water	68100.0	gal/yr	0.00064	9.524	415.1
Auxiliary fuel (.5%)	28.3	gal/yr	0.76	20.050	431.2
Labor (Table A3)	301.8	$/yr	-	9.524	2874.3
Maintenance (5% Table 14)	325.0	$/yr	-	9.524	3095.3
Ash disposal					0
Solid waste collection (Table 11)	-	-			9568.0
RDF purchase	86.8	ton/yr	$3.00	11.238	2926.4
		Total costs			21,342.5
		Budget estimate			21,340.0
CREDITS					
Fuel, coal (Table B4)	29.6	ton/yr	58.31	14.777	25,504.7
Fuel, oil (Table B4)	321.5	gal/yr	0.76	20.050	4899.0
O&M Bldg 32 (Table D1)	746.1	$/yr	-	9.524	7105.5
					37,509.2
		Budget estimate			$37,510.0

Comparative Economics

The four alternatives considered as part of this study are compared in Tables 18 and 19. The data in Table 18 are consolidated from Tables 1 through 17 and allow a direct comparison of the alternatives in terms of investment and the 25-year PV cost or savings. Table 19 compares the resource-recovery alternative to the *alternative of least capital investment*. The comparison is presented in terms of the SIR and "years-to-payback" the investment.

In essence, Table 19 documents that it is more economical for Federal facilities to buy solid waste processed at CCSF than to establish a separate, Federally operated solid waste processing facility at the Naval Shipyard Complex.

Sensitivity of SIR to Cost of RDF

It is noted in Appendix E that the overall economics of Alternatives C and D are dependent on the cost of the RDF. Table 19 shows that Alternatives C and D are the only alternatives greater than 1.00.

The SIRs were calculated for various costs per ton of RDF. Figure E1 illustrates that for a zero cost for RDF the SIR for Alternative D is 2.06; at $15.31/ton the resulting SIR is 1.00.

Table 18

Summary, Economic Analysis

		All Cost Data $000			
		Invest-ment Cost (Column 1)	25-yr PV O&M Cost (Column 2)	25-yr O&M Credits (Column 3)	25-yr O&M Cost (Sav) (Column 4)
A	Present practice of disposing of waste generated by Federal facilities at County operated sanitary landfills.	-0-	9880	-0-	9880
B	Federal resource-recovery facility, with two boilers, operating two shifts/day, 5 days/wk.	8500	14020	11030	2990
C	Regional resource-recovery facility, Level I, with two boilers operating two shifts/day, 6 days/wk.	13900	21990	30140	(8150)
D	Regional resource-recovery facility, Level II, with two boilers, operating three shifts/day, 5 days/wk.	14040	21340	37510	(16170)

*Col 4 = Col 2 - Col 3

Table 19

Savings to Investment Ratio

1. Least investment cost alternative: A

2. Test alternatives

	B	C	D
3. Net investment cost for test alternatives	8500	13900	14040
4. New investement cost for least investment alternative	0	0	0
5. Differential investment for test alternatives (Line 3 minus Line 4)	8500	13900	14040
6. PV annual cost for test alternatives	2990	-8150	-16170
7. PV terminal value for test alternatives	N E G L I G A B L E		
8. New future costs for test alternative (Line 6 minus Line 7)	2990	-8150	-16170
9. PV annual cost for least investment alternative	9880	9880	9880
10. PV terminal value for least investment alternative	N E G L I G A B L E		
11. Net PV future cost for least investment alternative (Line 9 minus Line 10)	9880	9880	9880
12. Differential savings for test alternative (Line 11 minus Line 8)	6890	18030	26050
13. SIR (Line 12 divided by Line 5)	0.81	1.30	1.86
14. Estimated years to payback	more than 25	13	5.5

5 CONCLUSIONS

This study concludes that it is technically feasible to build an energy resource-recovery facility in Charleston, SC, SMSA. The facility should be regional in nature; that is, it should recover the energy resource from solid waste generated by the civilian community as well as Federal facilities.

It is concluded that a Federal resource-recovery facility (Alternative B) is not economical and should not be pursued.

The regional resource-recovery facility, Level II (Alternative D) was the most economical alternative considered, as long as the cost of RDF to the Navy is less than $15.31/ton (FY82 dollars). Assuming the sale price of RDF to be $3.00/ton, the SIR for Alternative D is 1.86/1.0 with a payback period of approximately 5.5 years. The capital investment for Alternative D is estimated to be $14 million in FY82 dollars. The Federal government will conserve 29,600 tons of coal and 321,500 gallons of fuel, or 77.8×10^{10} Btu of fossil fuel each year, which represents 50 percent of the annual fuel consumption at the boiler plants 32, 123, NS2, NS44, and BOQs 5 and 6. Alternative D will reduce 86,800 tons/year of RDF produced by CCSF to 21,700 tons of ash. The 86,800 tons of RDF which can be processed in the Alternative D facility represent approximately 63 percent of the current annual production of RDF at CCSF. Alternative D would continue to allow resource recovery of ferrous metal at the CCSF.

If Alternative D is implemented, Charleston County will benefit from the sale of RDF: based on a RDF cost of $3.00/ton, the increase in income to Charleston County will be $260,000 in FY82 dollars ($161,500 in FY77 dollars). In addition, the County will conserve sanitary landfill space and reduce transportation costs as the distance from CCSF to the Charleston Naval Shipyard Complex is less than the anticipated distance to the new landfill.

6 RECOMMENDATIONS

The following recommendations are made as a result of this study:

1. A Federal resource-recovery facility to process Federal waste only should not be pursued.

2. A regional resource-recovery facility at the Charleston Naval Shipyard Complex to process a combination of Federal and civilian waste should be pursued.

3. The Navy should determine the willingness of Charleston County to deliver RDF to the proposed Alternative D facility. The cost per ton of RDF should be mutually determined. Particular attention should be given to the RDF sale cost; although an RDF sale in excess of $15.31/ton would make the proposed project economically unattractive to the Navy, a significantly lower than $3.00/ton RDF sale price would not allow Charleston County to realize a profit from CCSF RDF sales. If the discussions are successful, the Navy should build Alternative D, regional resource-recovery facility, Level II, to produce steam from RDF produced by Charleston County at the Charleston Naval Complex. This facility should consist of two waterwall boilers, each capable of producing 75,000 lb steam/hour.

4. If the discussions with Charleston County are not successful, the present practice of using County facilities (Alternative A) for the disposal of Federally generated MSW should be continued.

APPENDIX A:

METHOD OF ECONOMIC ANALYSIS AND BASIS OF CAPITAL COST ESTIMATE FOR RECOMMENDED RESOURCE-RECOVERY SYSTEM AND LABOR COST COMPUTATIONS

Method of Analysis

The general method of economic analysis follows guidance set forth in Document P-442, *Economic Analysis Handbook* (Naval Facilities Engineering Command [NAVFAC], 1971). The present value (PV) method is used to calculate initial investment, annual, and total costs of a project over an economic life of 25 years in terms of current dollars. For annually recurring costs, the method considers inflation rates associated with individual O&M cost elements plus a 10 percent interest rate.

To evaluate the costs of Alternatives B through D, each candidate system was considered alone. The economic analysis considers the costs of all activities from the generation of shredded waste to the transportation costs of disposing ash and residue in a landfill to the capital saved by the use of waste-generated steam. The analysis determines capital, annual, and total PV costs of a waste-to-energy system and if these costs are greater or less than the costs associated with the current waste management system.

When costs for all candidate systems have been established, a summary economic comparison is made according to procedures set forth in NAVFAC P-442. Candidate waste management alternatives are compared to determine the alternative which requires the lowest overall capital investment. The SIR for each alternative is then determined using the alternative which requires the least capital investment as the base of comparison. The recommended waste management alternative is generally the one with the most acceptable SIR payback period and overall capital investment.

As noted above, the economic method of analysis also considers inflation rates associated with individual O&M items plus a 10 percent interest rate to calculate a waste-to-energy system's annual PV costs.

The basis of this study's economic analysis was coordinated with the Southern Division, Naval Facilities Engineering Command. The short-term absolute escalation and long-term differential escalation rates are

an extension of rates determined by Department of Defense (DOD) policy[12] on energy conservation projects. The equivalent short-term multiplier is merely all short-term absolute escalation rates multiplied out. The 25-year PV equivalent multiplier is from NAVFAC Document P-442 (Table A1).

To estimate labor costs, various alternatives were "staffed" (Table A2). Hourly rates for personnel are as shown in Table A3. It was assumed in the preparation of Table A3 that the resource-recovery facility for Alternatives B through D would be contractor operated and as such would have a 40 percent combination fringe benefit and profit multiplier, as opposed to the standard 29.6 percent Government fringe benefit multiplier.

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12 *Solid Waste Management Collection, Disposal, Resource-Recovery and Recycling Program*, DOD Directive 4165.60 (DOD, 1976).

Table A1

Basis of Economic Analyses

Date of Cost Estimate: June 1977
First Year of Project Operation: FY82
Length of Economic Life: 25 Years
Geographic Adjustment Factor for Charleston, SC: 1.00

Unit Cost and Escalation Rates for Recurring (Annual) Cost Elements

Recurring Cost Element	Cost ($/Unit)	Short-Term Absolute Escalation Rates					Short-Term Equivalent Multiplier	DER+	Long-Term† 25-Year PV Equivalent Multiplier
		FY78	FY79	FY80	FY81	FY82			
Labor		7.0	6.6	6.5	6.5	6.5	1.38	0.0	9.524
Construction		7.0	6.5	6.5	6.5	6.5	1.38	0.0	9.524
Material		8.3	8.3	8.3	8.3	8.3	1.49	0.0	9.524
Maintenance	(5% of capital)	8.3	8.3	8.3	8.3	8.3	1.49	0.0	9.524
Coal	36.22/ton	10.0	10.0	10.0	10.0	10.0	1.61	5.0	14.777
Electricity	0.026/ kWh	16.0	16.0	16.0	16.0	16.0	2.10	6.0	16.303
RDF	(To be determined)	10.9	10.9	10.9	10.9	10.9	1.68	2.0	11.238
*Water	0.50/kgal	5.0	5.0	5.0	5.0	5.0	1.28	0.0	9.524
*Ferrous metals	18.00/ton	5.0	5.0	5.0	5.0	5.0	1.28	0.0	9.524
*Nonferrous metals	35.00/ton	5.0	5.0	5.0	5.0	5.0	1.28	0.0	9.524
*Paper	8.00/ton	5.0	5.0	5.0	5.0	5.0	1.28	0.0	9.524
*Glass	5.00/ton	5.0	5.0	5.0	5.0	5.0	1.28	0.0	9.524
Cardboard	12.00/ton	5.0	5.0	5.0	5.0	5.0	1.28	0.0	9.524
Vehicle fuel	0.55/gal	16.0	16.0	16.0	16.0	16.0	2.10	8.0	20.050
Vehicle O&M	0.1525/mile	7.0	6.6	6.5	6.5	6.5	1.38	0.0	9.524

* Materials reclaimed from waste stream. Unit value is net figure and excludes cost of marketing.
+ Differential Escalation Rate (DER).
† RDF rate estimated by authors, other rates specified by DOD policy.
PV Multiplier extracted from NAVFAC Document P-442.

Table A2

Plant Staffing
for Various Alternatives

<u>Alternative B</u>, Federal, two operating shifts/day, one clean-up shift/day
5 days/week

Shift No.	Plant Supervisor	Lead Boiler Operator	Boiler Operator	FEL Operator	Shredder Operator	Lead Laborer	Ash Handler	Laborer
1	1	1	1	1	1	-	-	1
2	-	1	1	1	1	-	-	1
3	-	-	-	-	-	1	1	1

<u>Alternative C</u>, Regional, two operating shifts/day, one clean-up shift/day,
6 days/week

Shift No.								
1	1	1	1	1	-	-	1	-
2	-	1	1	1	-	-	1	-
3	-	-	-	-	-	1	1	1

<u>Alternative D</u>, Regional, three operating shifts/day, five days/week.

Shift No.								
1	1	1	1	1	-	-	1	1
2	-	1	1	1	-	-	1	1
3	-	1	1	1	-	-	1	1

Table A3

Calculations of Labor Costs

Alternative B (Federal)

	Per Hour	Per Year*	W/Added+ Benefits
1 Plant supervisor	$8.00	$16640	$ 23296
2 Lead boiler operators	5.60	23296	32614
2 Boiler operators	5.25	21840	30576
2 Front-end loader operators	5.25	21840	30576
2 Shredder operators	4.90	20384	28538
1 Lead ash handlers	4.90	20384	28538
1 Ash handler	3.60	7488	10483
3 Laborers	3.60	22464	31450
		Total	$216070
			x1.38
		For FY82 labor	$296015

Alternative C (Regional)

	Per Hour	Per Year	W/Added+ Benefits
1 Plant supervisor	$8.00	$16640*	$ 23296
2 Lead	5.60	27955†	39137
2 Boiler operator	5.25	26208†	36691
2 Front-end loader operator	5.25	26208†	36691
1 Lead ash handler	4.90	12231†	17123
3 Ash handler	3.60	26957†	37740
1 Laborer	3.60	8986†	12580
		Total	$203258
			x1.38
		For FY82 labor	$278463

Alternative D (Regional)

	Per Hour	Per Year	W/Added+ Benefits
1 Plant supervisor	$8.00	$16640	$ 23296
3 Lead boiler operators	5.60	34933	48921
3 Boiler operators	5.25	32760	45864
3 Front-end loader operators	5.25	32760	45864
3 Ash handlers	3.60	22464	31449
3 Laborers	3.60	22464	31449
		Total	$226843
			x1.38
		For FY82 labor	$310775

*2080 hr/yr, FY77 salary rates
+Fringe benefits and profits 40 percent
†2496 hr/yr

APPENDIX B:

POTENTIAL FUEL CREDITS
FOR EACH ALTERNATIVE

The following conditions were used to calculate the potential fuel credits for resource-recovery Alternatives B through D.

In order to be counted as fuel credit, the steam produced from waste must be needed. The Federal facilities' average hourly steam load the first quarter of the year is 146,000 lb steam/hour (January to March); the second quarter (April to June) is 138,000 lb steam/hour; the third quarter (July to September) is 110,000 lb steam/hour; and the fourth quarter (October to December) is 122,000 lb steam/hour. The peak load demand for any quarter was 264,000 lb/hour. Eighty percent of the average steam load was set as the limit of useful steam available from a reasonably sized resource-recovery system. (To be 100 percent useful, a system would have to have a capacity of 264,000 lb/hour.)

The other limiting factor was the amount of energy available from waste. Table 2 lists the energy-recovery potential for waste generated at Federal facilities as 27.98×10^{10} Btu/year (Alternative B). The amount of RDF available from CCSF for the proposed resource-recovery system at the Charleston Naval Shipyard Complex is 23,330 tons/quarter. Based on an estimated lower heating value of 4790 Btu/lb, this is equivalent to a 223.2×10^{9}-Btu/quarter heat input.

Table B1 presents the calculations for the design capacity, annual steam production, and coal equivalent for Alternative B. Tables B2 and B3 present the steam needed to be produced from RDF and the amount of RDF required by Alternatives C and D, respectively. Table B4 presents an estimate of the fossil fuel savings under Alternatives C and D.

Table B1

Calculation of Potential Fuel Credit for Alternative B, Federal

Given:	Heat available (from Table 2)	27.98×10^{10}	Btu/yr
	Efficiency of present coal system	0.77	
	Efficiency of proposed system	0.72	
	Heat value of coal	12,300	Btu/lb
	Heat value of steam (160 psig, 420°F)	1227	Btu/lb
	Heat value of feed water (200°F)	168	Btu/lb
	Overcapacity design factor	1.25	
	Availability of system 245 or 260 days/yr =	0.942	
	Operations:	15 hr/day, 260 days/yr	

Find average hourly steam production, design capacity, and annual steam produced by the system.

$$\text{Average hourly steam production} = \frac{27.98 \times 10^{10} \times 0.72}{15 \text{ hr/day} \times 260 \text{ day/yr } (1227-168) \text{ Btu/lb steam}}$$

$= 48,780$ lb/hr (since this is only 45 percent of the average requirements in the lowest quarter, the steam is useful)

Design capacity

$= 1.25 \times$ average production

$= 1.25 \times 48,780 = 60970$ lb/hr

Use Two boilers (each 30,000 lb/hr)

$$\text{Steam produced} = \frac{27.98 \times 10^{10} \text{ Btu/yr} \times 0.72 \times 0.942}{1227-168}$$

$= 179.2 \times 10^6$ pounds/year

$$\text{Coal equivalent} = \frac{179.2 \times 10^6 \times (1227-168)}{0.77 \times 12,300 \text{ Btu/ton} \times 2000 \text{ lb/ton}} = 10,000 \text{ ton/yr}$$

Table B2

Alternative C, Regional
Projected Steam Production
and RDF Usage

Quarter	Present Average Steam Production Lb/hr	Steam* From RDF, Lb x 10^6	Heat Input From RDF, Btu x 10^9	RDF Needed, Tons
Jan-Mar	146,000	128.8	189.4	19770
Apr-June	138,000	122.1	179.6	18680
July-Sep	110,000	97.0	142.6	14890
Oct-Dec	122,000	107.6	158.2	16520
		455.5 lb steam/yr x 10^6		69,860 ton/yr

*Based on 80 percent of average; for 15 hour/day x 6 days/week x 13 weeks/quarter x 0.942 availability

Table B3

Alternative D, Regional
Projected Steam Production
and RDF Usage

Quarter	Present Average Steam Production Lb/hr	Percent Steam Satisfied by RDF	Steam* From RDF Lb x 10^6	Heat Input from RDF Btu x 10^9	RDF Tons
Jan-Mar	146,000	74.	151.8	223.2	23300+
Apr-June	138,000	78.	151.8	223.2	23300
July-Sep	110,000	80	124.1	182.5	19100
Oct-Dec	122,000	80	137.6	202.4	21100
			565.3		86800

*Based on 80 percent of average; for 15 hour/day x 6 days/week x 13 weeks/quarter x 0.942 availability

+For purposes of economics, 23,300 tons/quarter is considered the maximum RDF available from the Charleston County Shredder Facility.

Table B4

Calculations of Potential Fuel Credit for Alternatives C and D

Given:	Alternative C, lb steam/yr (from Table B2)	455.5×10^6 lb/steam
	Efficiency present coal system	.77
	Heat value of coal	12,300 Btu/lb
	Heat value of oil	150,000 Btu/gal
	Heat value of steam	1227 Btu/lb.
	Heat value of feed water (200°F)	168 Btu/lb
	Fraction of energy savings creditable to coal: 0.94	0.94
	Fraction of energy savings creditable to oil: 0.06	0.06

<u>Alternative C:</u>

Coal conserved:

$$\frac{0.94 \times 455.5 \times 10^6 \times (1227-168)}{0.77 \times 12{,}300 \times 2000 \text{ lb/ton}} = 23{,}940 \text{ ton/yr}$$

Oil conserved:

$$\frac{0.06 \times 455.5 \times 10^6 \times (1227-168)}{0.77 \times .15 \times 10^6} = 250{,}580 \text{ gal/yr}$$

<u>Alternative D:</u> lbs steam from RDF: 565.3×10^6 lbs steam (from Table B3)

Efficiency present coal system	.77
Heat value of coal	12,300 Btu/lb
Heat value of oil	150,000 Btu/gal
Heat value of steam	1227 btu/lb
Heat value of feed water (200°F)	168 Btu/lb
Fraction of energy saving creditable to coal 0.938	
Fraction of energy saving creditable to oil 0.062	

Coal conserved:

$$\frac{0.938 \times 565.3 \times 10^6 \, (1227-168)}{0.77 \times 12{,}300 \times 2000 \text{ lb/ton}} = 29{,}650 \text{ ton/yr}$$

Oil conserved:

$$\frac{0.062 \times 565.3 \times 10^6 \, (1227-168)}{0.77 \times 0.15 \times 10^6 \text{ Btu/gal}} = 321{,}500 \text{ gal/yr}$$

APPENDIX C:

SELECTION CRITERIA -- ALTERNATIVE B

Chapter 2 of this report documented the energy load (market) that exists for the energy available from solid waste generated by the civilian community and Federal facilities.

The purpose of this appendix is to outline (1) the criteria for the site of an Alternative B resource-recovery facility and (2) the criteria by which Federal facilities were selected to participate in Alternative B.

In an attempt to encourage a favorable SIR by reducing waste transportation costs, the site of Alternative B resource-recovery facility (including solid waste shredding equipment) was proposed at the geographic center of the waste generation of the Federal facilities in the Charleston SMSA. This site was very near the Naval Shipyard Complex -- the center of the energy load for Alternative B. Table C1 shows the estimated impact on transportation requirements, in ton-miles/year, if the Naval Shipyard Complex were the central waste receptor point, as opposed to the present practice of delivering Federal facility waste to CCSF. A resource-recovery facility at the Naval Shipyard Complex would cause an increase in transportation requirements of 65 percent for the VA Hospital, Coast Guard, and General Services Administration, both in terms of dollars and truck fuel. A review of Table C1 shows that these installations have very little (less than 7 percent) impact on the estimated energy available to the Federal waste stream. For these two reasons, no further consideration was given to their participation in a resource-recovery system. The VA Hospital, Coast Guard, and General Services Administration would continue their present practice of disposing of solid waste at CCSF.

The Federal facilities selected to participate in Alternative B were: the Charleston Naval Complex, Charleston Air Force Base, Naval Weapons Station and Missile Facility, Naval Medical Center, and the Charleston Army Depot.

In Alternatives C and D, all waste generated by Federal facilities, except the Naval Weapons Station, is taken to CCSF for processing. The Naval Weapons Station does not use CCSF facilities for two reasons:

1. In Alternative C, the haul distance to CCSF would be significantly increased compared to the distance to the landfill at Monk's Corner, the station's present disposal facility. More important, the quantity of RDF required by Alternative C is readily available from the CCSF.

2. In Alternative D, the amount of steam from CCSF RDF is essentially equal to the average amount of steam required for three quarters of the year (Table B3, Table C2).

Table C1

Present and Potential MSW Transportation Requirements in Ton-Miles Per Year

Installation	Ton-Miles per year: Present Disposal Point	Shipyard Complex	Change*	Percent Reduction
Naval Shipyard Complex and Family Housing	83400	5960	77440	1300
Charleston Air Force Base	66400	48260	18140	37
Naval Weapons Station and Missile Facility	56800	60840	-4040	-7
VA Hospital	1660	4990	-3330	-67
Naval Regional Medical Center	4680	780	3900	500
Charleston Army Depot	5400	3600	1800	50
Coast Guard	640	2560	-1920	-75
General Services Administration	580	2030	-1450	-72

*The negative sign indicates an increase in transportation requirement.

Table C2

Percentages of Steam Load Satisfied by
Alternatives B through D

Given:

a. Steam load of Building 32 (Table D1) $= 1114.6 \times 10^6$ lb steam/yr

b. Steam produced by Alternative B (Table B1) $= 179.2 \times 10^6$ lb steam/yr

c. Steam produced by Alternative C (Table B2) $= 455.3 \times 10^6$ lb steam/yr

d. Steam produced by Alternative D (Table B3) $= 565.3 \times 10^6$ lb steam/yr

Alternative	Percent Load Satisfied
$B = \frac{179.2}{1114.6}$	$\times 100 = 16.1$
$C = \frac{455.5}{1114.6}$	$\times 100 = 40.9$
$D = \frac{565.3}{1114.6}$	$\times 100 = 50.7$

APPENDIX D:

POTENTIAL O&M CREDITS TO THE
BUILDING 32 HEAT DISTRIBUTION SYSTEM

The Building 32 heat distribution system is the existing coal-fired steam plant. The annual O&M costs for operating this plant at 1114.6 x 10^6 lb steam/year are $1,073,600 (FY77 dollars). It is assumed that O&M costs are directly related to steam production. The resource-recovery systems of Alternatives B, C, and D will effect up to a 50 percent decrease in the steam load required of the Building 32 heat distribution system. The resulting savings in O&M costs will be from $236,000/year to $746,000/year, depending on the alternative selected for implementation. The computations for O&M credits of Alternatives B through D are shown in Table D1.

Table D1

O&M of Building 32 Boilers
Under Alternatives A through D

Alternative A (Present Practice)

Plant Operations, for 1114.6 x 10^6 lb steam/yr* = \$514,300/yr+

Plant Maintenance, for 1114.6 x 10^6 lb steam/yr* \$481,600/yr+

\$995,900 for FY76

Escalated to FY77:
\$995,900 x 1.078 = \$1,073,600/yr

Escalated to FY82:
\$1,073,600 x 1.37 = \$1,471,000/yr

Alternative B (Federal Facilities Only)

FY82 reduction in O&M cost to Building 32 boilers:

$$\frac{179.2 \times 10^6 \text{ lb steam/yr (Alternative B)}}{1114.6 \times 10^6 \text{ lb steam/yr (Building 32)}} \times \$1,471,000 = \$236,000/\text{yr}.$$

*The average hourly steam production is 129,000 lb/hour.
129 x 10^3 x 24 hour/day x 360 days/year = 1114.6 x 10^6 lb steam/year

+ Letter to Commander Naval Facilities Engineering Command from Commander Charleston Naval Shipyard, Subject: Submittal of Secondary Economic Analysis, pg 545, 21 December 1976, pg 3; These figures were carefully checked to avoid double counting. The figures do NOT include the cost of fuel.

Alternative C (Level I)

FY82 reduction in O&M cost of Building 32 boilers:

$$\frac{455.5}{1114.6} \times 10^6 \text{ lb steam/yr} \times 1,471,000 = \$601,100/\text{yr}$$

Alternative D (Level II)

FY82 reduction in O&M cost of Building 32 boilers:

$$\frac{565.3}{1114.6} \times 10^6 \text{ lb steam/yr} \times \$1,471,000 = \$746,100/\text{yr}$$

APPENDIX E:

POTENTIAL ANNUAL INCOME TO CHARLESTON COUNTY -- SENSITIVITY OF ECONOMICS TO RDF COST

The purpose of this appendix is to establish a basis for estimating the cost of the RDF to be used in the economic analysis of Alternatives C and D. These alternatives are the ones which interface with the existing CCSF. CCSF is defined as a resource-recovery facility because ferrous metals are separated from the RDF after shredding.

In order to simplify the analysis, it was assumed that the dump fee presently charged Federal facilities would remain constant, except for inflation; the dump fee for the ashes was assumed to be zero (more correctly, it will be built into the cost of the RDF).

The first step was to complete economic analysis of Alternative D, using $0.00/ton for RDF. The SIR was found to be 2.06. Assuming an SIR of 1.00, the economic analyses were recomputed solving for the cost/ton of RDF. The cost was found to be $15.31/ton. The data were plotted on a graph, Figure E1. Using a cost of $3.00/ton, the SIR was graphically determined to be 1.86. The $3.00/ton (FY82 dollars) is $1.86/ton (FY77 dollars). This is equivalent to one third the present dump fee of $5.58 (FY77 dollars).

The next step was to prepare Table E1 to determine whether the cost of RDF at one third the present dump fee would be attractive to Charleston County. Note that 1977 dollars are used in Table E1. The income to the county increases by $161,500/year (FY77 dollars) under this alternative. (Other benefits to the county, not quantified here, are indicated in Table E1.)

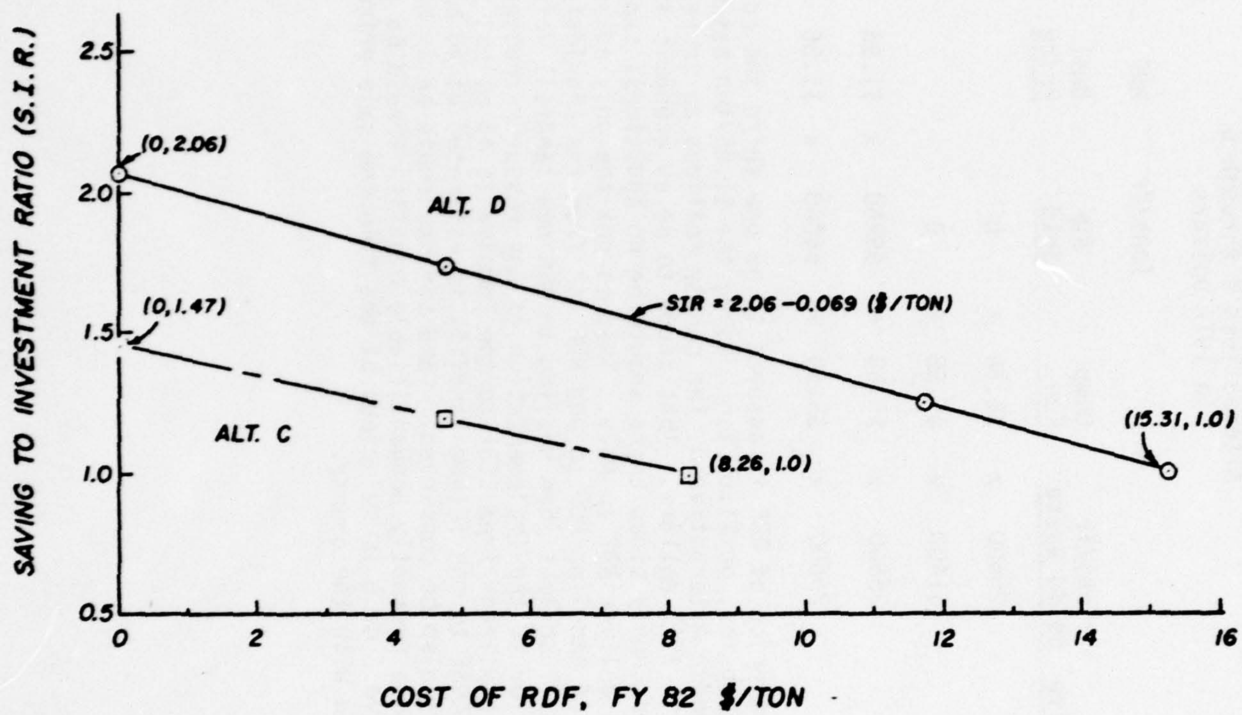

Figure E1. SIR plot of RDF costs.

Table E1

Annual Income to Charleston County
Waste Disposal System from
Alternatives A through D
In 1977 Dollars

Alternative	Tons/Yr Solid Waste		Dump Fee		Tons/Yr RDF Sold		RDF Unit Price	
A	25600	x	$5.58	+	0			= $142,800
B	11400	x	$5.58	+	0			= $ 63,600
C	25600	x	$5.58	+	69860	x	$1.86	= $272,800
D	25600	x	$5.58	+	86800	x	$1.86	= $304,300

Note: The price of RDF is assumed to be one third the cost of the present dump fee, or $1.86/ton. Using the $1.86/ton assumed unit price for RDF under Alternative D, the county realizes an increased income of $161,500 in 1977 dollars. This seems to be an economic incentive to Charleston County since there should be no additional capital investment needed to deliver RDF to Navy. This is not the only advantage to the county. The cost of handling RDF to and RDF ash from the Charleston Naval Shipyard Complex will be less than hauling to the new landfill which must be established prior to the implementation of any resource-recovery project. The round trip mileage from CCSF to the Complex is 15 miles; the round trip from the CCSF to the future landfill is estimated at 40 miles. Landfill space will also be conserved. Land savings could be as high as 5 acres/year. These presently unquantifiable benefits should be considered (if Alternative C or D is selected) at the time the sale price of RDF is negotiated with the county.

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